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Economic Effects of Banning Methyl Bromide for Soil Fumigation

Walter Ferguson
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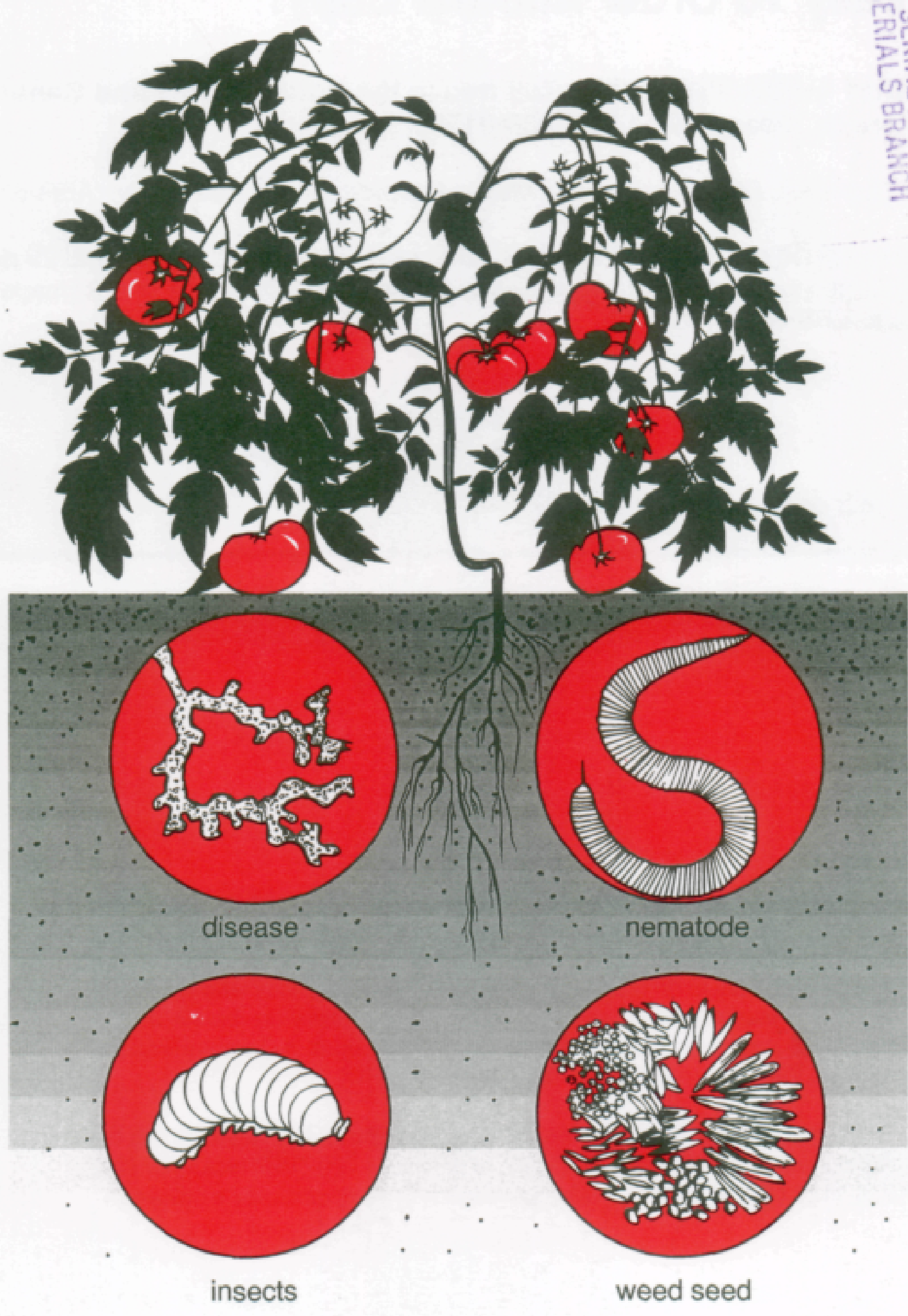

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Abstract

Methyl bromide (MB), a soil fumigant, may be banned by the U.S. Environmental Protection Agency (EPA) because of its potential to damage the ozone layer. Banning MB would cost about $1 billion annually in combined effects on growers' net revenue and consumer cost. Agricultural imports could moderate price increases and consumer losses but would magnify U.S. growers' losses. A crop-by-crop phaseout could reduce the economic effects of a cancellation or immediate suspension of MB. This report estimates the first year's effects on producers and consumers if the EPA cancels or suspends MB. The analysis includes 21 crops grown in 5 States--California, Florida, Georgia, North Carolina, and South Carolina.

Keywords: Methyl bromide, fumigation, soil, ban, growers, consumers

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The authors thank the benefits/assessment participants and contributors whose work made the estimates of the biological and economic analysis in this report possible. Appreciation is extended to the reviewers of the final drafts of the report: Ronald Davis and Kent Smith of the Agricultural Research Service, and Craig Osteen, Martin Shields, Philip Szmedra, and Jet Yee of the Economic Research Service.

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Preface

Beginning January 1, 1994, The Environmental Protection Agency, as a precaution against potential damage to the Earth's ozone layer, limited the production and importation of methyl bromide, via the Clean Air Act, to the 1991 levels of production and importation. In 2001, all production and importation of methyl bromide will cease. Use of methyl bromide inventories thereafter may continue for some registered uses and may be banned or canceled for others. However, if future research shows sufficiently reduced estimates of methyl bromide's impact on ozone depletion, its use and production could be permitted to continue.

In response to the concerns of a potential ban of methyl bromide uses on consumers and producers, the U.S. Department of Agriculture and State universities initiated a cooperative effort in 1991, under the National Agricultural Pesticide Impact Assessment Program, to assess the effects of potential restrictions of methyl bromide for soil fumigation and as a quarantine treatment. Extension Service and university biologists or scientists were the primary data sources for identifying the crops affected by a methyl bromide ban, nonchemical and fumigant alternatives to methyl bromide use, potential yield losses from a ban, and other related information.

This study provides an economic assessment of a methyl bromide ban of soil fumigation uses on 21 crops grown in California, Florida, Georgia, Kentucky (tobacco only), North Carolina, and South Carolina. The analysis assumes the immediate cancellation or suspension of methyl bromide as a soil fumigant for 21 crops. The crops include 10 fruit and nut crops (almonds, apples, apricots, cherries, citrus, grapes, nectarines, peaches, plums/prunes, and walnuts), 7 vegetable-berry crops (carrots, cucumbers, eggplants, peppers, strawberries, sweet potatoes, and tomatoes) and 4 miscellaneous crops (tobacco, melons, ornamentals, and forest seedlings).

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Summary

Methyl bromide (MB), a fumigant for controlling soil pests and protecting stored commodities, may be banned by the Environmental Protection Agency (EPA) as a precaution against potential damage to the Earth's ozone layer. A complete ban would cost the United States about $1 billion annually in combined effects on growers' net revenue and consumer cost. A crop-by-crop phaseout, however, could reduce the annual losses by at first banning MB only where its use is greatest and the benefits least. Such a planned phaseout would allow more valuable uses of MB to be retained for a number of years, while providing time for new alternatives to be developed and for growers and consumers to adjust.

This report estimates first-year effects on producers and consumers if the EPA cancels or suspends MB. The analysis covers 37.9 million pounds of MB used in 1991 in the production of 21 crops in 5 States (California, Florida, Georgia, North Carolina, and South Carolina), representing nearly 80 percent of the total 49 million pounds of MB used for soil fumigation. Crops analyzed include 10 fruit and nut crops, 8 vegetable or specialty crops, and 3 miscellaneous crops.

Producers in some States may experience extreme crop losses if the EPA bans the use of methyl bromide. Heavy losses are estimated for producers of cucumbers, eggplants, peppers, strawberries, and tomatoes in Florida; tomato producers in North Carolina, South Carolina, and Georgia; and strawberry producers in California.

Short-Term Effects of an MB Ban, Without Increased Agricultural Imports

The total short-term loss from an MB ban without an increase in imports is $867 million, which includes $441 million due to production losses of cucumbers, eggplants, melons, peppers, ornamentals, and forest seedlings. Further complicating the situation is the uncertainty with regard to Vorlex, the most widely used chemical alternative to MB. The sole manufacturer of Vorlex has indicated to the EPA that it plans to cease manufacturing Vorlex. Without Vorlex, the total annual loss from an MB ban without increased imports would increase from $867 million to $1.08 billion, a 25-percent increase. Of the additional loss, $197 million (92 percent) is attributed to fresh market tomatoes.

Longer Term Effects of an MB Ban, With Increased Agricultural Imports

In the longer run, assuming imports have increased and price rises moderated, the total annual loss, with continued availability of Vorlex, would decline slightly, from $867 to $856 million. Annual grower and consumer effects, however, would change dramatically. With imports and associated modified prices, growers' net revenue would decline from a gain of $133 million to a loss of $225 million. Consumer costs would decline from $559 to $189 million.

With the loss of Vorlex, after increased imports moderate price rises, the total annual loss is estimated to be $1.04 billion, a decline of $38 million from the shortrun case. Fresh market tomatoes would contribute $327 million (31 percent) of the $1.04 billion loss. Thus, agricultural imports could moderate price increases and consumer losses resulting from an MB ban, but would magnify U.S. growers' financial losses. Countries whose exports must be fumigated with methyl bromide or Vorlex before entry to the U.S. market could lose market share.

Effects of a Crop-by-Crop Phaseout of MB Use

The ratio of economic effect per pound of methyl bromide used in soil fumigation ranges from a loss of $109 per pound for forest seedlings to $2 per pound for grapes. A crop-by-crop phaseout could reduce those costs by first banning MB only where its use is greatest and the benefits least. For example, banning registered uses of MB in production of tomatoes, grapes, strawberries, and melons would reduce the quantity of MB used by 60 percent, while reducing the associated economic benefits by only 35 percent. The crops selected for phaseout of MB use could change if new fumigant alternatives become available.

The economic assessment is a partial analysis of the effects on producer net return and consumer cost, as total welfare effects would also include the environmental benefits of a methyl bromide ban. The welfare effects derived are primarily shortrun effects. If the use of methyl bromide does have a negative effect on the environment, the present value of future environmental benefits of a ban could exceed the short-term benefits of methyl bromide availability.

The analysis presented in this report is a cooperative effort by the U.S. Department of Agriculture (USDA) and State universities under the National Agricultural Pesticide Impact Assessment Program (NAPIAP).

Economic Effects of Banning Methyl Bromide for Soil Fumigation

Walter Ferguson and Armand Padula

Introduction

Methyl bromide (MB) is a fumigant that has been widely used since the 1930's to control soil pests and protect stored commodities. In 1992, methyl bromide became a concern of a group of 124 nations (which included the United States) whose members signed the Montreal Protocol, a treaty to protect the ozone layer. The parties to the Montreal Protocol declared that methyl bromide contributes to the depletion of the stratospheric ozone layer, with resulting adverse environmental consequences. In November 1992, the Montreal Protocol treaty was amended to require developed country parties to freeze by 1995 the production and consumption of methyl bromide at 1991 levels, with exemptions for quarantine and preshipment uses. Further action under the Montreal Protocol will be based on upcoming scientific and technology assessments.

The Environmental Protection Agency (EPA) has taken a more stringent precautionary measure than the Montreal Protocol by initiating action under the Clean Air Act that requires a phaseout of methyl bromide uses by the year 2001.

In response to these concerns, the U.S. Department of Agriculture (USDA) and State universities, in a cooperative effort under the National Agricultural Pesticide Impact Assessment Program (NAPIAP), assessed the effects of potential restrictions on uses of methyl bromide. This report analyzes the short-term economic implications for the use of alternatives to MB in the production of 21 crops grown in California, Florida, Georgia, North Carolina, and South Carolina.

The primary data sources were Extension Service and university biologists or scientists working in a research or advisory capacity involving crops that would be affected by an MB ban. The crops studied include 10 fruit and nut crops (almonds, apples, apricots, cherries, citrus, grapes, nectarines, peaches, plums/prunes, walnuts); 8 vegetable and specialty crops (carrots, cucumbers, eggplants, melons, peppers, strawberries, sweet potatoes, and fresh tomatoes); and 3 miscellaneous crops (forest seedlings, ornamentals, and tobacco). The economic effects derived are based on 1991/92 crop year estimates of available MB alternatives, treated acres, and production losses that could change with atypical changes in weather, pest population outbreaks, loss of available alternatives, or new nonchemical and chemical pest control strategies.

When the study of an MB ban was initiated in 1991, alternative chemical fumigants included metam-sodium, Vorlex (methyl isothicyanate + 1,3-D), and dazomet. Vorlex's sole manufacturer does not plan to reregister the fumigant. With the exception of California, 1,3-D will continue, and dazomet is limited to uses associated with tobacco and other nonfood items.

Scope of Economic Effects

Although the methyl bromide ban assessment is limited to 21 crops produced in 5 States, the price effects of reduced yields affect all consumers, as well as growers in other States. The 5-State study area for the 10 fruit and nut crops produces from 100 percent of the U.S. almond, nectarine, and walnut crops, to 11 percent of the apple and cherry crops (fig. 1). For four of the eight vegetable crops for which total U.S. data are available, the area for economic analysis represents a major proportion of the selected crops - carrots (94 percent), strawberries (83 percent), sweet potatoes (51 percent), and fresh market tomatoes (86 percent). For tobacco only, Kentucky is added to represent a 6-State study area (no tobacco grown in California) of 79 percent of the total U.S. tobacco crop. The analysis examines the economic effects of losing Vorlex as an alternative to methyl bromide due to the manufacturer's voluntary cancellation of the Vorlex registration. Such a

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cancellation would affect melons, ornamentals, peppers, strawberries, tobacco, and tomatoes.

The economic analysis is limited to the first year of a ban, and thus does not take into account the multiple-year strategies of crop rotations, allowing land to lie fallow, construction of greenhouses, and other longer term scenario alternatives and strategies considered in the biological analysis (USDA, NAPIAP). When large price effects are estimated, however, the analysis considers the potential for imports to offset production losses and moderate price increases in the longer term and the economic implications of increased imports for growers and consumers.

The analysis assumes the immediate cancellation or suspension of all registered crop uses. Under the Clean Air Act, production and use of MB would be phased out by the year 2001. Such a phaseout would likely have a smaller economic effect on changes in control cost and on crop price. A phaseout could allow time for new chemical or nonchemical controls to be developed and adopted by growers to replace current MB uses. If replacement controls allow growers, during a phaseout, to maintain the yields achieved using MB, there would be considerably less effect on crop prices and associated consumption cost than indicated in this assessment. During a phaseout, price increases could be further dampened by increased production in other States where MB is not needed, or by imports from countries not affected by the phaseout. Smaller price increases would mean smaller increases in grower revenue and consumer cost.

Methyl Bromide Use and Available Chemical Alternatives

An estimated 64 million pounds of methyl bromide were used in 1990 in the United States. Uses included postharvest food/crops (5 million pounds), structures (4 million pounds), chemical intermediate manufacturing (6 million pounds), and preplant soil fumigation (49 million pounds). An estimated 37.9 million pounds of methyl bromide were used in 1991 to treat 155,091 acres on the 21 crops in the 5-State study area. Four of the crops accounted for 72 percent of the total 37.9 million pounds: tomatoes (35 percent), strawberries (15 percent), peppers (12 percent), and tobacco (10 percent) (fig. 2). Rate of use averaged 245 pounds per acre for the 21 crops, ranging from 445 pounds per acre for tobacco plant beds to 137 pounds per acre for melon crops (table 2).

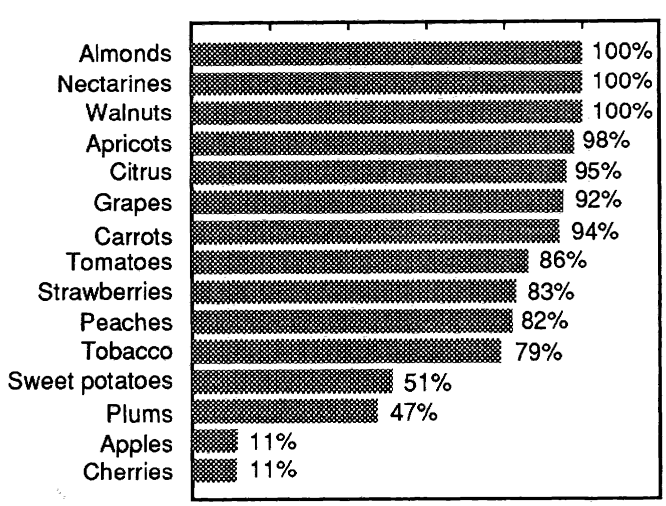
With a methyl bromide ban, biologists indicate that metam-sodium could be the major feasible chemical alternative for most of the fruits, nuts, vegetables, and tobacco in the study area.

Vorlex (methyl isothiocyanate + 1,3-D) and chloropicrin were considered by biologists as alternatives that also

Figure 1

Proportion of U.S. production in five selected States[1] (California, Florida, Georgia, North Carolina, and South Carolina)

The five-State area produces from 100 percent of the U.S. almond, nectarine, and walnut crops, to 11 percent of the apple and cherry crops.

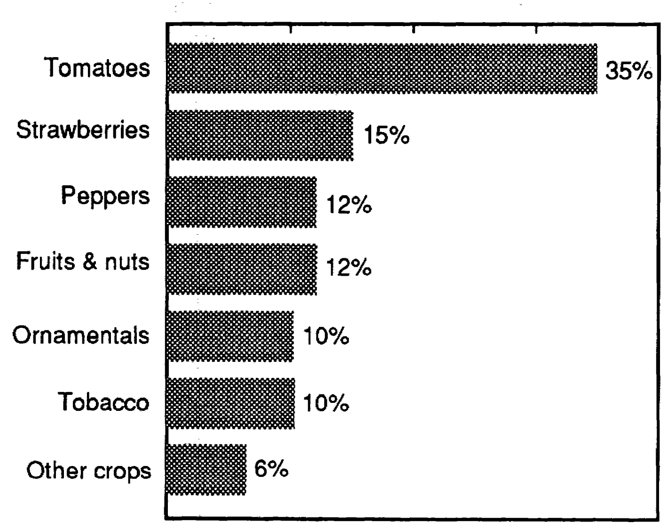


[1] Data not available for cucumbers, eggplants, melons, ornamentals, peppers, and forest seedlings. Tobacco data include Kentucky's production.

Figure 2

Proportion of total 37.9 million pounds of methyl bromide used in California, Florida, Georgia, Kentucky (tobacco only), North Carolina, and South Carolina

Four crops (tomatoes, strawberries, peppers, and tobacco) accounted for 72 percent of total methyl bromide use.



could be used for some vegetables. The registered uses of dazomet are limited to nonfood items. For tobacco plant beds, biologists listed dazomet, metam-sodium, and Vorlex as methyl bromide alternatives. Since the manufacturer of Vorlex will not be seeking reregistration, Vorlex will not be available in the near future for use in producing vegetables, field crops, ornamentals, nursery stock, and plant bed seedlings (NAPIAP, 1992). Additional production losses and cost changes were estimated assuming that Vorlex would not be an alternative on methyl bromide-treated acres. The economic implications of those changes were estimated. With the exception of California, the use of alternative chemical fumigant 1,3-D will continue.

Assumptions of the Analysis

The estimated production costs and price effects assume that growers will use alternative chemical fumigants that cost more for some crops and are generally less effective. The change in cost using the alternative fumigants prior to planting does not include additional treatments during the growing season of fungicides, nematicides, insecticides, and herbicides that growers may use to maintain production at prior levels. Further, the analysis does not take into account the cost and price effects of individual growers planting increased acreage to maintain prior production levels. Thus, these simplifying assumptions imply that the change in costs involves only alternative fumigants, and the price effects assume the same number of acres will be planted after a methyl bromide ban.

In the following sections, the effects of a methyl bromide ban on grower net revenue and consumer cost are indicated for 15 of the 21 study crops. National data on acres, production, and price elasticities were not available to project changes in consumer cost for six crops--cucumbers, eggplants, peppers, melons, ornamentals, and forest seedlings. For these crops, constant market prices are used to approximate values of production losses.

The analysis of implications of imports on prices and revenues focuses on strawberries, tomatoes, and tobacco. Increased imports would moderate price increases, reduce consumer losses, and increase producer financial losses. These three crops would have the largest proportional production losses among the 15 crops for which price changes were estimated. The assumptions create a worst-case scenario for U.S. producers, because imports are assumed to increase in response to higher prices while U.S. production is not. U.S. planted acreage and production of these crops could increase, which would reduce economic losses to producers and consumers. The resulting economic loss would be underestimated, however, because acreage and production of crops previously grown on those acres would decline, and economic losses caused by effects on prices, consumers, and producers of those crops are difficult to enumerate.

Based on discussions with commodity experts in USDA's Economic Reseach Service, we assumed that 70 percent of tomato production losses, 90 percent of tobacco production losses, and 15 percent of strawberry production losses would be replaced by imports. For tomatoes, most losses would occur in Florida. Mexico produces tomatoes during many of the same months as Florida and could increase exports to the U.S. market. Since tobacco imports are increasing, we assumed that imports from a variety of countries could replace production losses. For strawberries, imports provide a small portion of domestic consumption, and there is no exporter whose increased shipments to the United States could replace a large portion of the production losses.

Economic Effects on Growers

To assess the economic effects of using methyl bromide alternatives on growers' net revenues, the study used national estimates to project prices of a methyl bromide ban on 15 crops--almonds, apples, apricots, cherries, citrus, grapes, nectarines, peaches, plums/prunes, walnuts, carrots, strawberries, sweet potatoes, tomatoes, and tobacco. If growers use the available alternatives for these crops, the short-term price increases stemming from reduced production would offset a $19 million increase in control costs, resulting in an estimated $133 million total gain in net revenue (fig. 3). The change in net revenue would range from a $103 million gain to tobacco growers to a $31 million loss to strawberry growers (table 3).

The increased control costs include $15 million for tomato (fresh market) growers, with minimal declines in cost for fruit and nut crops. The above estimates of changes in grower revenue do not include the effect of a methyl bromide ban on cucumbers, eggplants, melons, peppers, ornamentals, and forest seedlings. The price increases resulting from production losses for these crops could not be estimated because national estimates of acres grown and production are not available.

The large price increases for strawberries, tomatoes, and tobacco would likely encourage longer term increases in imports that would, in turn, moderate the price increases. Based on the assumed import responses for those commodities, there would be an annual $225 million loss in net revenue for the 15 crops for which price changes were computed. Losses would be about $86 million for tomatoes, $98 million for tobacco, and $41 million for strawberries.

Vegetable and specialty crop growers in some States would experience extreme crop losses (up to 100 percent) if they could not use methyl bromide (table 10). Estimates of crop losses include: California strawberries, 14 percent; Florida strawberries, 59 percent; Florida cucumbers, 100 percent; Florida eggplants, 100 percent; Florida peppers, 85 percent; and fresh market tomatoes (Florida, 19 percent; Georgia, 45 percent; North Carolina, 81 percent; and South Carolina, 31 percent).

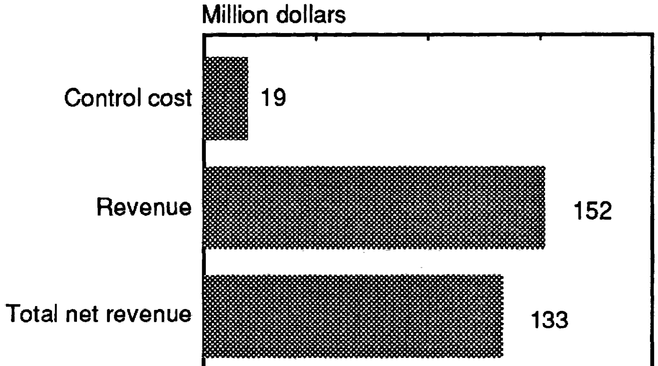
If Vorlex were also unavailable, production losses caused by a methyl bromide ban would increase, particularly on tomatoes (46 percent) grown in Florida (table 10). In the short run, net revenues on the 15 crops for which price changes were esimated would increase by $153 million per year (table 3). In the longer run, assuming increases in imports, net revenue would decrease by $322 million per year. This net revenue loss would be about $100 million per year more than if Vorlex were available, and tomato producers would bear most of that additional loss.

For the individual grower, the effectiveness and cost of methyl bromide alternatives and extent of methyl bromide-treated acres may determine whether the grower continues to produce a crop. Individual growers may continue to produce a crop affected by the ban as long as the grower can cover the costs of seed, fertilizer, pesticide, and other variable costs. If the grower's revenue does not cover costs of equipment, land, and other fixed costs, however, the grower will likely discontinue production.

Figure 3

Effects of a methyl bromide ban on growers of 15 crops

In the short term, growers' net revenue and consumer costs would increase.



Economic Effects on Consumers

The short-term price effects and reduced production of the 15 crops would cost consumers an estimated $559 million, which includes commodities exported as well as those consumed domestically (table 3). In the longer run, after imports increase and price rises level off, annual consumer losses would decline to $189 million. Without Vorlex as an alternative to methyl bromide, annual consumer losses would be $782 million in the short run, but would decline to $269 million in the longer run (table 3).

For fruit and nut crops, methyl bromide treatments generally account for a relatively small proportion of the total crop acres. As a result, the minor losses in production (1 percent or less) have negligible effects on price (table 11). The total short-term increase in consumption cost is estimated at $31 million, ranging from an $18.6 million increase in the cost of citrus to less than a $500,000 increase in the cost of apricots and cherries.

For vegetables, the lack of feasible alternatives to methyl bromide may result in other crops replacing Florida cucumber and eggplant production in the first year of a ban. Consumers of fresh market tomatoes would lose $225 million and consumers of strawberries would lose $76 million (table 3). The likely short-term effects of the higher prices of affected crops would increase the demand and prices of substitute fruits and vegetables. In the longer run, annual consumer losses for fresh market tomatoes and strawberries would decline to $70 million and $65 million. Without Vorlex as an alternative to methyl bromide, annual consumer losses would be $443 million and $79 million for tomatoes and strawberries in the short run and $147 million and $68 million in the longer run (table 3).

For tobacco, the use of methyl bromide alternatives would increase costs to consumers by an estimated $228 million. In the longer run, losses to tobacco consumers would decline to $23 million per year. Without Vorlex as an alternative, consumer losses would be $230 million per year in the short run and $23 million in the longer run (table 3).

Evaluation of Production Losses Using Constant Prices

In deriving the effect of a change in production, use of a "projected price" involves estimating the change in price associated with a change in production. For example, a drop in production generally results in a higher crop price. If national estimates of production, acres planted, and demand elasticities are not available to project the new price with a loss in production, the use of a "constant market price" is sometimes used to reflect the value of the total economic loss. Use of a constant price simply involves multiplying the average market price times the loss in production.

A pesticide ban generally results in higher prices in response to reduced production from less efficient control. The use of constant prices to value crop loss, as compared with higher projected crop prices, understates the banned pesticide user's loss in revenue, and ignores increases in nonuser revenue and consumer cost. Conversely, the use of projected higher prices associated with lower production generally raises "all growers'" revenues (methyl bromide users and nonusers) and increases consumption cost. For example, use of projected instead of constant price would increase the value of production loss (using methyl bromide alternatives) of tomatoes and strawberries by an estimated 22 and 14 percent (table 11). Thus, the difference in projected versus constant price would offset the effect of lower production on revenue from treated acres, add to the revenue from untreated acres, and increase the cost of consumption.

If there is a minor difference between the projected and constant price (1 percent or less), the difference in the derived "total effect" (producer plus consumer effects) may be minor. As data limitations prevent calculation of projected prices, the differences in projected and constant prices are not known. However, the total effect of a methyl bromide ban on each of the six crops is derived as a "rough measure" in absence of other available measures.

Total Economic Effects of an MB Ban

The total short-term loss of a methyl bromide ban is an estimated $867 million, which includes an increase in net returns (change in revenue minus change in cost) and an increase in commodity cost to consumers (or welfare loss) (fig. 4). For 15 of the 21 crops, the sum includes a projected $133 million increase in growers' net revenue, and a $559 million cost to consumers. The $867 million loss includes a $441 million loss due to production losses for cucumbers, eggplants, melons, peppers, ornamentals, and forest seedlings. The total economic loss for these crops was estimated as the sum of production loss assuming constant prices, and the change in pest control costs. The value of the estimated production loss of the six crops, using methyl bromide alternatives, is estimated at $426 million (table 3, footnote 1). In the longer run, when imports have increased and price rises moderated, the total loss from soil uses would decline slightly to $856 million per year. However, the annual consumer and producer effects for the 15 crops for which price changes were estimated would change dramatically: a $225 million loss for producers and a $189 million loss for consumers.

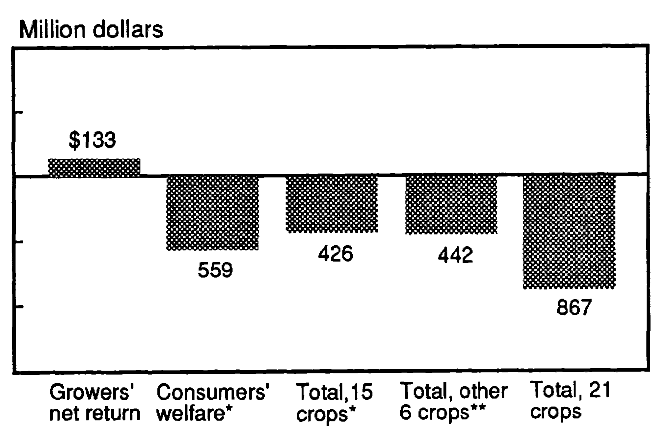
The voluntary cancellation of Vorlex would dramatically increase the effect of a methyl bromide ban (table 3). In the short run, the total annual loss would increase by $214 million (25 percent) to $1.08 billion per year. Of the additional loss, $197 million (92 percent) is attributed to fresh market tomatoes. For the 15 crops for which price changes were estimated, consumer losses would be $782 million per year, while net revenue increased $153 million per year. For the other six crops, the total annual loss would increase by $11 million to $453 million. In the longer run, after increased imports moderate price rises, the total annual loss is estimated to be $1.04 billion, a decline of $38 million from the shortrun case. Fresh market tomatoes would contribute $327 million (31 percent) of the annual loss. For the 15 crops for which price increases were estimated, consumer losses would moderate to $269 million per year, but net revenues would decline by $322 million per year.

In the following sections, the major and minor uses of methyl bromide are discussed for 11 of the 21 study crops with the highest negative total economic effects (change in grower net revenue plus change in consumer cost).

Figure 4

Effects of a methyl bromide ban on growers and consumers, and total effects in California, Florida, Georgia, Kentucky (tobacco only), North Carolina, and South Carolina

The total short-term loss from a methyl bromide ban is an estimated $867 million, which includes a $559 million cost to consumers.



*Evaluated using projected market price.
** Evaluated using constant market price.

Major Methyl Bromide Uses

Ornamentals, peppers, strawberries, tobacco, and tomatoes account for an estimated 82 percent of the 37.9 million pounds of active ingredients used for the 21 crops. Banning methyl bromide use on these crops would have an estimated total effect of $100 million or more per crop. The quantity of methyl bromide used, acres treated, cost of alternatives, estimated production losses, and economic effects are discussed for individual crops in the following sections.

Ornamentals. The ornamental crop category includes methyl bromide-treated nursery plant bed and field sites in the production of flowers, shrubs, and other nursery plants. As the ornamental category includes a wide range of plant types and varieties, time and data limitations required grouping of various plant types and estimates of constant (instead of projected) dollar valuations of changes in yield (USDA, NAPIAP). An estimated 3.7 million pounds of methyl bromide is used to treat an estimated 12 percent of the 50,000 acres of ornamentals in California, 84 percent of the 1,782 acres in Florida, and 90 percent of the 1,500 acres in North Carolina (tables 4, 6). The major alternative to methyl bromide in greenhouses is steam treatment. Alternatives in the field include metam-sodium, dazomet, Vorlex, and hand-weeding. Soil-less planting mixtures are used in South Carolina as an alternative to methyl bromide treatment. (Soil-less planting mixtures, which exclude natural soil, include such mineral materials as vermiculite and similar ingredients.) Using methyl bromide alternatives, the change in control cost would range from an estimated decrease of $159 per acre in California to an increase of $6,314 per acre in Florida (table 7). Using constant prices, the estimated reduced production of the various crops using the methyl bromide alternatives is valued at $150 million. Without Vorlex, the annual production loss would be valued at $155 million.

Peppers (bell, chili, red, and miscellaneous peppers). An estimated 4.5 million pounds of methyl bromide are used to treat about 21,968 acres of various varieties of peppers in California, Florida, Georgia, and North Carolina (tables 2, 5). Treated acreage ranges from 19,635, or 85 percent of the Florida acres, to 594, or 3 percent of the California acres (table 6). The change in treatment cost per acre using methyl bromide alternatives ranges from an increase of $191 per acre in Florida to a decrease of $161 per acre in Georgia. No alternatives to methyl bromide were indicated by California biologists. Metam-sodium and Vorlex were indicated as potential alternatives to methyl bromide in Florida, Georgia, and North Carolina. Production losses using the indicated alternatives would range from 85 percent of the crop in Florida to 3 percent in California and North Carolina. Using constant prices, the estimated 223,351 tons of estimated reduced production, using the methyl bromide alternatives, is valued at $127 million (tables 3, 9). Without Vorlex as an alternative, 235,140 tons of peppers, valued at $134 million, would be lost annually (tables 3, 9).

Strawberries. An estimated 5.7 million pounds of methyl bromide is used to treat 89-99 percent of the strawberry acres in California and Florida, 33 percent in North Carolina, and 67 percent in South Carolina (tables 2, 6). The four States account for about 83 percent of the U.S. commercial strawberry production (table 1). Using methyl bromide alternatives (metam-sodium, chloropicrin, and Vorlex) would lower production by 104,809 tons in the four States, ranging from an estimated 59-percent loss in Florida production to 12 percent in North Carolina (tables 9, 10).

Use of the methyl bromide alternatives would increase control costs by an estimated $1.1 million (table 8). In response to lower production, the price of strawberries is projected to increase by 14 percent, with an associated decline in growers' net revenue of $31 million and an increase in consumers' cost of $76 million. A ban of methyl bromide use on strawberries would result in an estimated loss of $107 million. In the longer run, imports would have a minimal effect on the total economic effect. Prices would increase by 12 percent, net revenue would decline by $41 million per year, and consumers would lose $65 million per year.

Without Vorlex as an alternative, strawberry production loss is estimated to be 109,652 tons, and the total annual economic loss would increase to $112 million (tables 3, 9). In the short run, prices would increase about 14 percent, consumers would lose $79 million per year, and net revenues would decline $33 million per year. In the longer run, prices would increase about 12 percent, consumers would lose $68 million per year, and net revenues would decline $43 million per year (tables 3, 11).

Tobacco (all varieties). An estimated 3.7 million pounds of methyl bromide are used to treat 95-100 percent of the total 6,416 acres of tobacco plant beds in Georgia, North Carolina, and South Carolina, and 50 percent of the 4,000 acres in Kentucky (tables 2, 4, and 5). These States and Florida, a minor tobacco-producing State, account for about 79 percent of the U.S. commercial tobacco production. Kentucky data on production loss and acres treated were included in the five-State study area because Kentucky is a major tobacco-producing State. Growers using the alternatives of dazomet, metam-sodium, and Vorlex would increase control cost by about $5.2 million and lower production by an estimated 34,264 tons of tobacco (tables 3, 9). The production losses reflect 10 percent of the production in Georgia and North Carolina (table 10).

In response to lower production, the price of tobacco is projected to increase by 9 percent, with an associated increase in growers' net revenue of $103 million, and an increase in consumers' cost of $228 million. The total effect on the changes in growers' revenues plus consumers' cost is an estimated loss of $126 million. In the longer run, when imports increase, price increases would moderate to less than 1 percent, consumers would lose $23 million per year, net revenues would decline $98 million per year, and the total economic loss would be $121 million per year.

Without Vorlex as an alternative, annual tobacco production would decrease by 34,552 tons (table 9). The shortrun price increase would be 9 percent, consumers would lose $230 million per year, net revenues would increase $103 million per year, and the total economic loss would be $127 million per year (tables 3, 11). In the longer run, tobacco prices would increase 1 percent, consumers would lose $23 million per year, net revenues would decline $99 million per year, and the total economic loss would be $121 million per year.

Tomatoes (fresh market). An estimated 13.1 million pounds of methyl bromide are used to treat 61 percent of the fresh market tomato acreage in the 5-State study area, which accounts for about 86 percent of U.S. commercial production (tables 1, 2, and 6). Using methyl bromide alternatives (Vorlex and metam-sodium) would increase control costs by an estimated $15.3 million and lower production by 214,972 tons, ranging from 81 percent of North Carolina's production to 1 percent of California's production (tables 9, 10).

The price of tomatoes is projected to increase by 22 percent in response to lower production, with an associated increase in growers' net revenue of $61 million and an increase in consumers' cost of $225 million. The total effect on the changes in growers' revenues plus consumers' cost is an estimated loss of $164 million of the benefits attributed to methyl bromide availability. In the longer run, when imports increase, price increases would moderate to 7 percent, consumers would lose $71 million per year, net revenues would decline $86 million per year, and the total economic loss would be $157 million per year.

If Vorlex is not available as an alternative to methyl bromide, annual production losses for fresh market tomatoes would more than double to 457,768 tons (table 9). Florida production would contribute 88 percent of the additional production loss. In this situation, Florida production is estimated to decline 46 percent. Economic effects would increase dramatically. In the short run, prices would increase 48 percent, consumers would lose $443 million per year, and net revenues would increase $82 million per year (tables 3, 11). The total annual economic loss would be $361 million, more than 2.2 times the loss if Vorlex were available as an alternative. In the longer run, when imports increase, prices would increase 14 percent, consumers would lose $147 million per year, and net revenues would decline $181 million per year. The total annual economic loss would be $327 million, about 2.1 times the loss if Vorlex were available as an alternative.

Minor Methyl Bromide Uses

Biologists indicate that the availability of feasible control alternatives to methyl bromide is limited or nonexistent in some States for citrus (for postharvest transportation), cucumbers, eggplants, forest seedlings, grapes, and melons. In terms of the proportion of the 21-crop total, these crops account for minor amounts of methyl bromide use--citrus (less than 1 percent), cucumbers (less than 1 percent), eggplants (1 percent), forest seedlings (less than 1 percent), grapes (5 percent), and melons (5 percent).

Citrus (fresh market). An important use of methyl bromide in citrus crops is in postharvest fumigation by the Florida Department of Agriculture, which uses trucks to maintain control of the Caribbean fruit fly. There are no alternatives to methyl bromide for this purpose, which accounts for an estimated 102,000 pounds of methyl bromide used in fumigating about 4,080 citrus-loaded trucks annually (table 2). The loss of methyl bromide availability for fumigating trucks would result in less revenue to Florida growers, as citrus is diverted to processing and culling. Assuming an estimated 76,000-ton loss to fresh market citrus, and a projected 1-percent increase in price, the total economic effect is an estimated $25 million of loss in benefits attributed to methyl bromide availability.

Cucumbers (fresh and processing markets). An estimated 1,700 acres of cucumbers in Florida are double-cropped on methyl bromide-treated land where tomatoes or peppers were harvested. Other potential chemical alternatives, metam-sodium and Vorlex, would not be sufficiently effective to allow a marketable crop to be produced. There are no acceptable nonchemical alternatives to methyl bromide. Thus, Florida's estimated 189,150 tons of lost production is valued at $72 million using constant prices. The analysis assumes that no other crops would be double-cropped with tomatoes or peppers in the first year of the ban.

Eggplants. An estimated 410,000 pounds of methyl bromide are used to treat 100 percent of the 2,050 acres of eggplants grown in Florida. Methyl bromide is used at a rate of 200 pounds per acre with a treatment cost of $199 per acre. Biologists indicated there are no feasible chemical or nonchemical alternatives to methyl bromide. Nonchemical alternatives to control weeds include flaming, at $350 per acre, and hand hoeing, at $120 per acre. Without methyl bromide, other Florida crops would be grown on land currently planted to eggplants. Using constant prices, the estimated 26,200 tons of loss in production using the methyl bromide alternatives is valued at about $12 million.

Forest seedlings. The forest seedlings crop site category includes a wide variety of tree seedling types and varieties. Time and data limitations required use of estimated constant (instead of projected) dollar valuations of production loss. An estimated 320,074 pounds of methyl bromide are used to treat an average of 17 percent of the 1,446 acres of forest seedling acres in the 5 study States (tables 4, 6). Alternatives to methyl bromide include chloropicrin, dazomet, metam-sodium, Vorlex, glyphosate, and hand weeding. Change in control cost would range from an estimated decline of $396 per acre in California to an increase of $58 per acre in Florida. Using constant prices, the short term or first-year production loss is valued at an estimated $34.8 million. The long-term economic implications without methyl bromide could be considerably more important than the first-year estimate, assuming new alternatives to maintain yield and quality do not become available and lower quality seedlings are produced and planted.

Grapes. An estimated 1.9 million pounds of methyl bromide are used to treat 4,838 or 0.6 percent of the California acres in the 5-State study area (tables 2, 6). The study States account for about 93 percent of the U.S. commercial production (table 1). Using metam-sodium and nonfumigant nematicide alternatives would lower control costs by about $1.2 million and lower production by an estimated 13,061 tons (tables 9, 10).

In response to lower production, the price of grapes is projected to increase by less than 1 percent, with an associated increase in growers' net revenue of about $3 million and an increase in consumers' cost of $6 million. The total effect is an estimated loss of $3 million of the benefits attributed to methyl bromide availability.

Melons (watermelon, honeydews, and miscellaneous melons). An estimated 2 million pounds of methyl bromide are used in the study States to treat about 14,330 acres of honeydew melons and watermelons. Treated acreage ranges from 10,600 acres (20 percent of the total) in Florida to 380 acres (10 percent of the total) in North Carolina (tables 5, 6). For the five States, the change in treatment cost per acre using methyl bromide alternatives ranges from a decline of $200 in South Carolina to a $91 increase in Georgia and North Carolina. Metam-sodium and Vorlex were indicated as potential alternative treatments in California, Georgia, and North Carolina. Production losses would range from 23 percent of the crop in Florida to 3 percent or less in the other four States. Using constant prices, the estimated 92,750 tons of estimated reduced production is valued at $29.7 million. The voluntary cancellation of Vorlex would have little effect on melon production, and control costs would increase about $100,000 per year (table 8).

Estimates of the proportion of acres planted, production losses, and the associated economic effects are for the 1991/92 crop years. The estimates could change with atypical weather, pest population outbreaks, or new nonchemical and chemical pest control strategies. In the next section, cumulative economic effects and ratios of economic effects and methyl bromide use (quantity used, acres treated) are examined as potential guidelines for phasing out uses of methyl bromide.

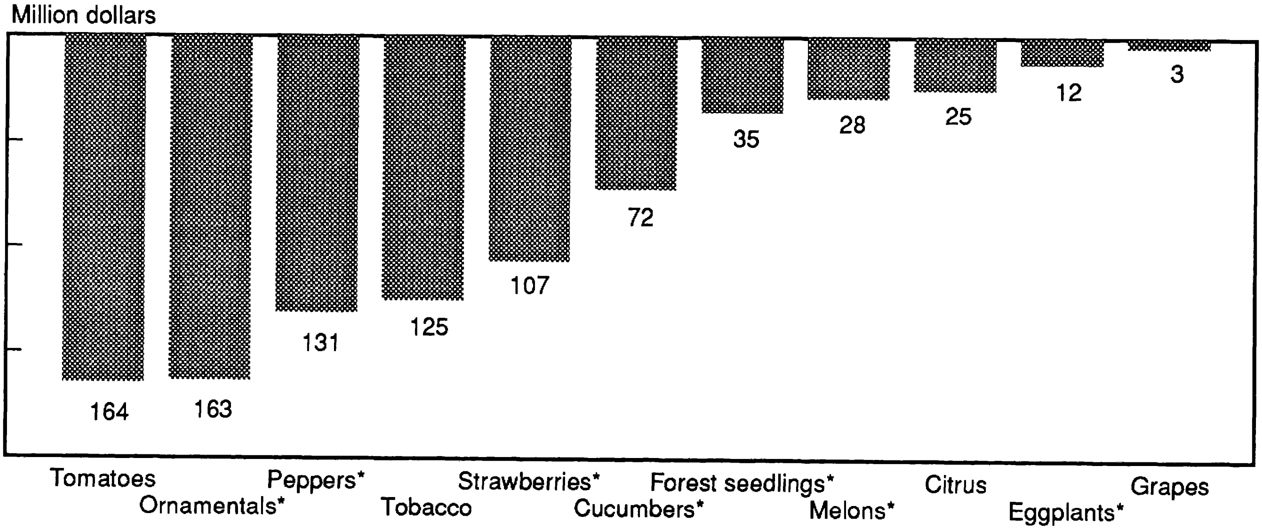
A Phaseout of Methyl Bromide Uses

Of the 11 crops with estimated total economic effects of $3 million or over per crop, the effects range from an estimated $164 million for tomatoes to $3 million for grapes (fig. 5). A phaseout could focus on major reductions in quantity of methyl bromide use without the adverse economic effects that generally follow an immediate cancellation of all uses. For example, a phaseout plan could include reducing the quantity of methyl bromide use (for example, 70-90 percent) in the first 3-4 years, while maintaining the most important economic benefits of methyl bromide use (for example, 70-90 percent) for one or two decades longer, or until feasible alternatives are available. A phaseout of methyl bromide use in tomato production would reduce the use of methyl bromide by 35 percent of the 37.9 million pound total while reducing by 19 percent the $856 million benefits attributed to methyl bromide availability (see box). Adding a restriction on grapes would decrease methyl bromide use by an additional 5 percent, or a total of 40 percent, and decrease the benefits of methyl bromide by less than 1 percent. The banning of registered methyl bromide uses in production of tomatoes, grapes, strawberries, and melons would reduce the quantity of methyl bromide use by an estimated 60 percent and associated economic benefits of methyl bromide by 35 percent. The priority of selection could change if new fumigant alternatives become available, or if the effects of crop use on human health is considered, such as tomatoes versus tobacco.

Figure 5

Total methyl bromide ban effects, selected crops in California, Florida, Georgia, Kentucky (tobacco only), North Carolina, and South Carolina

Total economic effects of a methyl bromide ban per crop range from $164 million for tomatoes to $3 million for grapes.



*Evaluated using constant market price.

The phaseout crop selection could consider total economic effects as a ratio of amounts used and acres treated. For example, a ratio of the total economic effect of a methyl bromide ban per pound used in providing control for a crop would have an estimated range of $109/lb. for forest seedlings to less than $20/lb. for strawberries, melons, tomatoes, and grapes (fig. 6). (Postharvest citrus, double-cropped cucumbers, and crops with minor effects are not included.) Thus, based on each pound of active ingredient removed from use, the loss of methyl bromide availability and associated benefits would be more costly to society for forest seedlings than for the other four crops. Similar results are obtained using a ratio of the total economic effect per methyl bromide-treated acre, which indicates a $40,472/acre loss in benefits for forest seedlings, compared with less than $2,500/ acre loss for tomatoes, grapes, melons, and tobacco (fig. 7).

The economic effects are based generally on estimates of yield losses and acres treated. The results of scientifically designed tests or surveys are frequently not available to the experts in determining an estimate. However, the estimates of economic effects can provide useful guidelines for minimizing the cost to society of phasing out crop registration of methyl bromide use. The priority of crops selected for continued methyl bromide registration, using cumulative effects and ratio analysis, could result in major reductions in methyl bromide use within a few years, while avoiding the adverse economic effects of using less effective fumigant alternatives.

Percentage of total methyl bromide used and total economic effect, selected crops

A phaseout of methyl bromide (MB) use in tomato production would reduce MB use by 35 percent, while reducing by only 19 percent the benefits attributed to MB.

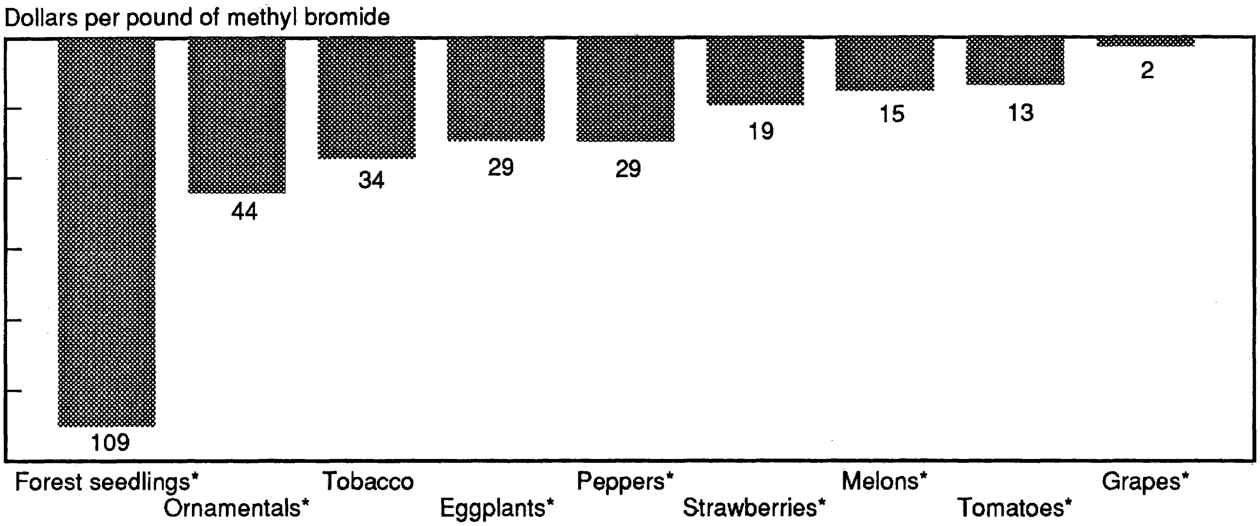
	Percentage of total MB use (37.9 mil.lb.)		Percentage of total effects ($856 million)[1]	
	Per crop	*Cumulative total*	*Per crop*	*Cumulative total*
Tomatoes	35	35	19	19
Grapes	5	40	0.4	19
Strawberries	15	55	12	32
Melons	5	**60**	3	**35**
Peppers	12	72	15	50
Tobacco	10	82	14	64
Ornamentals	10	92	19	83
Other crops	8	100	17	100
Total	100		100	

[1]The $856 million assumes increased imports of tomatoes, strawberries, and tobacco, and the continued availability of Vorlex, the most widely used MB alternative.

Figure 6

Economic effect per pound of methyl bromide use, by crop, in study States

The economic effect of a methyl bromide ban for soil fumigation ranges from a loss of $109 per pound of methyl bromide for forest seedlings to $2 per pound for grapes.

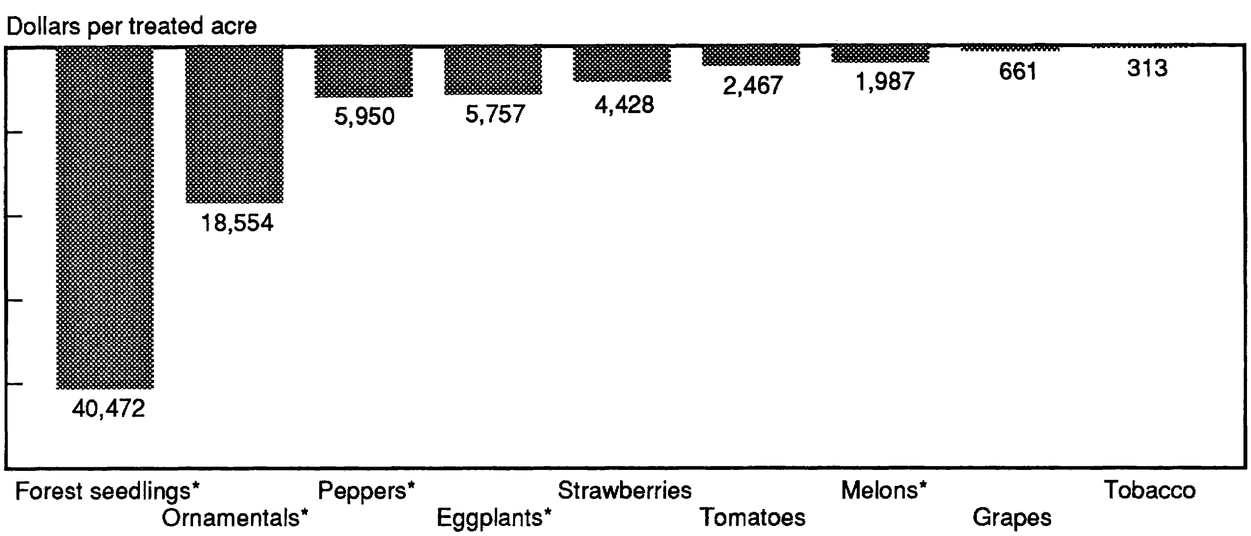


*Evaluated using constant market price.

Figure 7

Economic effect per MB-treated acre, by crop, in study States

The economic effect per MB-treated acre ranges from a loss of $40,472 per acre for forest seedlings to $313 per acre for tobacco.



*Evaluated using constant market price.

Five-State Total Effects Extrapolated to U.S. Level

The proportion of U.S. production represented by the 21 crops ranges from 100 percent of the commercial production of almonds and nectarines to 47 percent of the production of plums and prunes. For 15 of the 21 crops for which national estimates of production are available, the 5-State percentages of U.S. production are used to extrapolate the 5-State total effects to the U.S. level. The total effects would increase by $82 million, from the $414 million 5-State effect to a $496 million national effect, if we assume no additional effects of a ban on the other 6 crops (cucumbers, eggplants, melons, peppers, ornamentals, and forest seedlings) outside the 5-State area (table 13). Most of the additional effects outside the 5-State area would be to producers and consumers of strawberries ($21 million), tomatoes ($26 million), and tobacco ($33 million).

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Table 1--Scope of economic analysis study area--States, crops, and production

The 5-State study area for 21 crops represents from 100 percent of the U.S. almond, nectarine, grape, and walnut crops to 11 percent of the apple and apricot crops.

Crop	U.S. 1989-91 average production	Selected States, proportion of U.S. production	1989-91 average production					
			Total	California	Florida	Georgia	North Carolina	South Carolina
	1,000 tons	Percent	1,000 tons					
Fruits/nuts:								
Almonds	270	100	270	270	--	--	--	--
Apples	4,898	11	526	376	--	13	118	19
Apricots	110	98	108	108	--	--	--	--
Cherries	262	11	28	28	--	--	--	--
Citrus	11,790	96	11,365	2,898	8,467	--	--	--
Grapes	5,716	92	5,275	5,270	--	3	2	0.5
Nectarines	219	100	219	219	--	--	--	--
Peaches	1,210	82	991	799	--	68	10	115
Plums/prunes	851	47	403	403	--	--	--	--
Walnuts	235	100	235	235	--	--	--	--
Vegetables:								
Carrots	1,434	94	1,343	810	534	--	--	--
Cucumbers	--	--	384	57	189	--	95	42
Eggplants	--	--	26	--	26	--	--	--
Melons	--	--	962	403	362	55	33	109
Peppers	--	--	650	296	225	77	52	--
Strawberries	633	83	528	454	63	--	7	4
Sweet potatoes	599	51	306	36	--	36	218	16
Tomatoes, fresh	1,717	86	1,473	481	874	37	13	69
Field crops:								
Tobacco[1]								
Field transplanted	776	79	610	--	9	45	303	54
Ornamentals	--	--	--	--	--	--	--	--
Forest seedlings	--	--	--	--	--	--	--	--

-- = Data not available.

[1]Selected States total includes 199,418 tons of tobacco produced in Kentucky.

Table 2--Methyl bromide use on selected crops, 1991

Four crops accounted for 72 percent of the total 37.9 million pounds of methyl bromide used: tomatoes (35 percent), strawberries (15 percent), peppers (12 percent), and tobacco (10 percent).

Crop	State(s)	Acres treated	Rate	Methyl bromide use: Total	Proportion
		Acres	Pounds per acre	Pounds	Percent
Fruits/nuts:					
Almonds	CA	1,803	400	721,200	1.9
Apples	CA	450	400	180,000	0.5
Apricots	CA	75	400	30,000	0.1
Cherries	CA	224	400	89,600	0.2
Citrus[1]	FL	0	0	102,000	0.3
Grapes	CA	4,838	400	1,935,200	5.1
Nectarines	CA	791	400	316,400	0.8
Peaches	CA	1,586	400	634,400	1.7
Plums/prunes	CA	740	400	296,000	0.8
Walnuts	CA	481	400	192,400	0.5
Subtotal		10,988	409	4,497,200	11.9
Vegetables:					
Carrots	CA	9	225	2,025	0.0
Cucumbers[2]	FL	0	0	0	0.0
Eggplants	FL	2,050	200	410,000	1.1
Melons	CA,FL,GA,NC,SC	14,329	137	1,962,600	5.2
Peppers	CA,FL,GA,NC	21,968	205	4,512,400	11.9
Strawberries	CA,FL,NC,SC	24,049	237	5,708,100	15.1
Sweet potatoes	CA	45	200	9,000	0.0
Tomatoes, fresh mkt.	CA,FL,GA,NC,SC	63,466	207	13,111,100	34.6
Subtotal		125,916	204	25,715,225	67.8
Miscellaneous crops:					
Tobacco[3]					
Plant Bed	GA,NC,SC	8,275	445	3,682,375	9.7
Ornamentals	CA,FL,NC	9,047	410	3,712,550	9.8
Forest seedlings	CA,FL,GA,NC,SC	865	370	320,074	0.8
Subtotal		18,187	424	7,714,999	20.3
Total, selected crops		155,091	245	37,927,424	100.0

[1] Use of methyl bromide is on post harvest fumigation of trucked citrus in Florida.
[2] Cucumbers double-cropped after harvest of tobacco or pepper on MB-treated acres.
[3] Tobacco MB use includes treatment of 2,000 acres of plant beds in Kentucky.

Table 3--Projected effects on growers and consumers of a methyl bromide ban, with and without Vorlex, and with and without imports

The expected voluntary cancellation of Vorlex by its manufacturer would increase the effect of an MB ban from an estimated $867 million short-term loss in combined effects on growers' net revenue and consumer cost to $1,081 million. Agricultural imports could moderate price increases and consumer losses but would magnify U.S. growers' losses.

Crop	With imports: Change in growers': Control cost	With imports: Change in growers': Revenue	With imports: Change in growers': Net revenue	With imports: Change in consumer cost	With imports: Total effect	Without imports: Change in growers': Revenue	Without imports: Change in growers': Net revenue	Without imports: Change in consumer cost	Without imports: Total effect
				Million dollars					
With Vorlex									
Crops with losses valued using projected market prices:									
Fruits/nuts:									
Almonds	-0.856	0.3	1.2	0.5	0.7	0.3	1.2	0.5	0.7
Apples	-0.038	0.4	0.4	0.8	-0.4	0.4	0.4	0.8	-0.4
Apricots	-0.002	0.0	0.0	0.2	-0.2	0.0	0.0	0.2	-0.2
Cherries	-0.006	0.7	0.7	0.4	0.3	0.7	0.7	0.4	0.3
Citrus	-0.490	-6.4	-5.9	18.6	-24.5	-6.4	-5.9	18.6	-24.5
Grapes	-1.210	1.8	3.0	6.2	-3.2	1.8	3.0	6.2	-3.2
Nectarines	-0.109	0.1	0.2	1.1	-0.9	0.1	0.2	1.1	-0.9
Peaches	-0.218	0.1	0.3	1.1	-0.8	0.1	0.3	1.1	-0.8
Plums/prunes	-0.019	0.1	0.1	0.5	-0.4	0.1	0.1	0.5	-0.4
Walnuts	-0.012	0.7	0.7	1.6	-0.9	0.7	0.7	1.6	-0.9
Subtotal	-2.959	-2.2	0.7	31.0	-30.3	-2.2	0.7	31.0	-30.3
Vegetables:									
Carrots	0.003	0.0	0.0	-0.3	0.3	0.0	0.0	-0.3	0.3
Strawberries	1.092	-29.8	-30.9	75.7	-106.6	-40.2	-41.3	65.2	-106.5
Sweet potatoes	0.007	0.1	0.1	-0.2	0.3	0.1	0.1	-0.2	0.3
Tomatoes, fresh	15.400	76.0	60.6	224.6	-164.0	-70.9	-86.3	70.3	-156.6
Subtotal	16.502	46.3	29.8	299.8	-270.0	-111.0	-127.5	135.0	-262.5
Tobacco									
Field transplanted	0.000	107.7	107.7	228.0	-120.3	-93.0	-93.0	23.1	-116.1
Plant bed	5.088	0.0	-5.1	0.0	-5.1	0.0	-5.1	0.0	-5.1
Subtotal	5.088	107.7	102.6	228.0	-125.4	-93.0	-98.1	23.1	-121.2
Total, 15 crops	18.632	151.8	133.1	558.8	-425.7	-206.2	-224.9	189.1	-414.0
Crops with losses valued using constant market prices[1]:									
Cucumbers	0.000	--	--	--	-72.1	--	--	--	-72.1
Eggplants	-0.408	--	--	--	-11.8	--	--	--	-11.8
Melons	-1.200	--	--	--	-28.5	--	--	--	-28.5
Peppers	3.585	--	--	--	-130.7	--	--	--	-130.7
Ornamentals	13.282	--	--	--	-163.4	--	--	--	-163.4
Forest seedlings	0.208	--	--	--	-35.0	--	--	--	-35.0
Total, 6 crops	15.467	--	--	--	-441.5	--	--	--	-441.5
Total, selected crops	34.099	--	--	--	-867.2	--	--	--	-855.5

Continued

Table 3--Projected effects on growers and consumers of a methyl bromide ban, with and without Vorlex and with and without imports--Continued

Crop	Without imports: Change in growers': Control cost	Revenue	Net revenue	Change in consumer cost	Total effect	With imports: Change in growers': Revenue	Net revenue	Change in consumer cost	Total effect
	Million dollars								
Without Vorlex									
Crops with losses valued using projected market prices:									
Fruits/nuts:									
Almonds	-0.856	0.3	1.2	0.5	0.7	0.3	1.2	0.5	0.7
Apples	-0.038	0.4	0.4	0.8	-0.4	0.4	0.4	0.8	-0.4
Apricots	-0.002	0.0	0.0	0.2	-0.2	0.0	0.0	0.2	-0.2
Cherries	-0.006	0.7	0.7	0.4	0.3	0.7	0.7	0.4	0.3
Citrus	-0.490	-6.4	-5.9	18.6	-24.5	-6.4	-5.9	18.6	-24.5
Grapes	-1.210	1.8	3.0	6.2	-3.2	1.8	3.0	6.2	-3.2
Nectarines	-0.109	0.1	0.2	1.1	-0.9	0.1	0.2	1.1	-0.9
Peaches	-0.218	0.1	0.3	1.1	-0.8	0.1	0.3	1.1	-0.8
Plums/prunes	-0.019	0.1	0.1	0.5	-0.4	0.1	0.1	0.5	-0.4
Walnuts	-0.012	0.7	0.7	1.6	-0.9	0.7	0.7	1.6	-0.9
Subtotal	-2.959	-2.2	0.7	31.0	-30.3	-2.2	0.7	31.0	-30.3
Vegetables:									
Carrots	0.003	0.0	0.0	-0.3	0.3	0.0	0.0	-0.3	0.3
Strawberries	0.829	-31.9	-32.7	78.9	-111.6	-42.6	-43.4	68.0	-111.4
Sweet potatoes	0.007	0.1	0.1	-0.2	0.3	0.1	0.1	-0.2	0.3
Tomatoes, fresh	7.856	89.6	81.7	442.5	-360.8	-172.7	-180.6	146.8	-327.4
Subtotal	8.694	57.8	49.1	520.9	-471.8	-215.2	-223.9	214.3	-438.2
Tobacco									
Field transplanted	0.000	108.5	108.5	229.9	-121.4	-93.8	-93.8	23.3	-117.1
Plant bed	5.088	0.0	-5.1	0.0	-5.1	0.0	-5.1	0.0	-5.1
Subtotal	5.088	108.5	103.4	229.9	-126.5	-93.8	-98.9	23.3	-122.2
Total, 15 crops	10.824	164.1	153.2	781.8	-628.6	-311.2	-322.1	268.6	-590.7
Crops with losses valued using constant market prices[1]:									
Cucumbers	0.000	--	--	--	-72.1	--	--	--	-72.1
Eggplants	-0.408	--	--	--	-11.8	--	--	--	-11.8
Melons	-1.121	--	--	--	-28.6	--	--	--	-28.6
Peppers	1.471	--	--	--	-135.3	--	--	--	-135.3
Ornamentals	15.445	--	--	--	-170.0	--	--	--	-170.0
Forest seedlings	0.208	--	--	--	-35.0	--	--	--	-35.0
Total, 6 crops	15.595	--	--	--	-452.8	--	--	--	-452.8
Total, selected crops	26.418	--	--	--	-1,081.4	--	--	--	-1,043.5

-- = Not available.

[1]For these crops, the estimates of "total effect" reflect the change in cost (first column above) plus the "value" of production loss (below). Value of production loss is derived using constant market price, as follows:

	Price/ton (Dollars)	Production loss (tons)	Value (Million dollars)
Cucumbers	381	189,150	72.1
Eggplants	466	26,200	12.2
Melons	320	92,750	29.7
Peppers	569	235,140	133.9
Ornamentals	*	*	154.6
Forest seedlings	*	*	34.8
Total			437.2

* Price/ton, production loss, and value of ornamental- and forest seedling-loss estimates are from biological analysis (USDA, NAPIAP). [Value-of-loss formula used: (Number of seedlings x acres treated) x (percent yield loss x price per seedling) + adjustments, for example, unplanted acres.]

Table 4--Production acres, selected crops, 1990-91

Acreage studied ranged from 806,300 acres of citrus to 1,446 acres of forest seedlings.

Crop	California	Florida	Georgia	North Carolina	South Carolina	Selected States
			Production acres			
Fruits/nuts:						
Almonds	430,000	--	--	--	--	430,000
Apples	32,600	--	--	--	--	32,600
Apricots	19,303	--	--	--	--	19,303
Cherries	12,000	--	--	--	--	12,000
Citrus	250,600	555,700	--	--	--	806,300
Grapes	779,400	--	1,700	600	340	782,040
Nectarines	29,100	--	--	--	--	29,100
Peaches	68,786	--	20,000	4,200	31,800	124,786
Plums/prunes	105,700	--	--	--	--	105,700
Walnuts	181,000	--	--	--	--	181,000
Vegetables:						
Carrots	56,000	--	--	--	--	56,000
Cucumbers	4,700	17,100	--	25,000	10,800	57,600
Eggplants	--	2,050	--	--	--	2,050
Melons	106,400	53,000	6,000	3,982	2,200	171,582
Peppers	23,700	23,100	5,000	6,718	--	58,518
Strawberries	19,500	5,400	--	2,000	1,100	28,000
Sweet potatoes	8,300	--	5,000	35,500	33,500	82,300
Tomatoes, fresh	38,000	55,800	3,100	3,387	4,000	104,287
Miscellaneous crops:						
Tobacco[1]						
Field transplanted	--	6,767	41,500	289,000	49,500	558,050
Plant bed	--	--	850	4,566	1,000	10,416
Ornamentals	50,000	1,782	--	1,500	--	53,282
Forest seedlings	150	138	798	150	210	1,446

-- = No commercial production acreage reported.

[1]Selected States total for tobacco include Kentucky's 178,050 production acres and 4,000 plant bed acres.

Table 5--MB-treated acres, selected crops, 1990-91

Acres treated by methyl bromide range from 63,466 acres of fresh market tomatoes to 9 acres of carrots.

Crop	California	Florida	Georgia	North Carolina	South Carolina	Selected States
				Acres treated		
Fruits/nuts:						
Almonds	1,803	--	--	--	--	1,803
Apples	450	--	--	--	--	450
Apricots	75	--	--	--	--	75
Cherries	224	--	--	--	--	224
Citrus	N.A.	--	--	--	--	0
Grapes	4,838	--	--	--	--	4,838
Nectarines	791	--	--	--	--	791
Peaches	1,586	--	--	--	--	1,586
Plums/prunes	740	--	--	--	--	740
Walnuts	481	--	--	--	--	481
Vegetables:						
Carrots	9	--	--	--	--	9
Cucumbers[1]	--	--	--	--	--	--
Eggplants	--	2,050	--	--	--	2,050
Melons	559	10,600	1,800	380	990	14,329
Peppers	594	19,635	1,000	739	--	21,968
Strawberries	17,306	5,346	--	660	737	24,049
Sweet potatoes	45	--	--	--	--	45
Tomatoes, fresh	592	54,684	2,790	1,400	4,000	63,466
Miscellaneous crops:						
Tobacco[2]						
Field transplanted	--	6,767	41,500	289,000	49,500	386,767
Plant bed	--	--	850	4,475	950	8,275
Ornamentals	6,204	1,493	--	1,350	--	9,047
Forest seedlings	18	138	399	100	210	865

-- = Acreage not treated with methyl bromide.

[1]Estimated 1,700 acres of cucumbers double-cropped with MB-treated tomatoes or peppers.

[2]Selected States total for tobacco includes 2,000 MB-treated plant bed acres in Kentucky.

Table 6--Proportion of planted acres treated with MB, by selected States and crops, 1990-91

The proportion of planted acres treated with methyl bromide ranges from 100 percent of the selected States' eggplant acreage to less than 10 percent of the fruit and nut, carrot, melon, and sweet potato acreage.

Crop	California	Florida	Georgia	North Carolina	South Carolina	Selected States
	Acres treated (percent of planted acres)					
Fruits/nuts:						
Almonds	0.4	--	--	--	--	0.4
Apples	1.4	--	--	--	--	1.4
Apricots	0.4	--	--	--	--	0.4
Cherries	1.9	--	--	--	--	1.9
Citrus	--	--	--	--	--	--
Grapes	0.6	--	--	--	--	0.6
Nectarines	2.7	--	--	--	--	2.7
Peaches	2.3	--	--	--	--	1.3
Plums/prunes	0.7	--	--	--	--	0.7
Walnuts	0.3	--	--	--	--	0.3
Vegetables:						
Carrots	0.0	--	--	--	--	0.0
Cucumbers[1]	--	--	--	--	--	--
Eggplants	--	100.0	--	--	--	100.0
Melons	0.5	20.0	30.0	9.5	45.0	8.4
Peppers	2.5	85.0	20.0	11.0	--	37.5
Strawberries	88.7	99.0	--	33.0	67.0	85.9
Sweet potatoes	0.5	--	--	--	--	0.1
Tomatoes, fresh	1.6	98.0	90.0	41.3	100.0	60.9
Field crops:						
Tobacco[2]						
Plant bed	--	--	100.0	98.0	95.0	69.3
Ornamentals	12.4	83.8	--	90.0	--	79.4
Forest seedlings	12.0	100.0	50.0	66.7	100.0	17.0

-- = Acreage not treated with methyl bromide.

[1]Estimated 1,700 acres of Florida cucumbers double-cropped with MB-treated tomatoes or peppers.

[2]Selected States total for tobacco includes 2,000 MB-treated plant bed acres in Kentucky.

Table 7--Per-acre change in control cost using MB alternatives, with and without Vorlex

The generally lower per-acre cost of treating the current methyl bromide-treated acres indicates lower cost of alternatives as well as no available alternatives.

Crop	California	Florida	Georgia	North Carolina	South Carolina	California	Florida	Georgia	North Carolina	South Carolina
					Dollars					
With Vorlex						Without Vorlex				
Fruits/nuts:										
Almonds	-475	--	--	--	--	-475	--	--	--	--
Apples	-85	--	--	--	--	-85	--	--	--	--
Apricots	-25	--	--	--	--	-25	--	--	--	--
Cherries	-25	--	--	--	--	-25	--	--	--	--
Citrus	--	--	--	--	--	--	--	--	--	--
Grapes	-250	--	--	--	--	-250	--	--	--	--
Nectarines	-138	--	--	--	--	-138	--	--	--	--
Peaches	-138	--	--	--	--	-138	--	--	--	--
Plums/prunes	-25	--	--	--	--	-25	--	--	--	--
Walnuts	-25	--	--	--	--	-25	--	--	--	--
Vegetables:										
Carrots	300	--	--	--	--	300	--	--	--	--
Cucumbers	--	--	--	--	--	--	--	--	--	--
Eggplant	--	-199	--	--	--	--	-199	--	--	--
Melons	-75	-107	91	91	-200	-75	-107	116	116	-200
Peppers	-75	191	-161	91	--	-75	66	134	116	--
Strawberries	50	125	--	-175	-485	50	82	--	-175	-485
Sweet potatoes	154	--	--	--	--	154	--	--	--	--
Tomatoes, fresh	-675	299	-245	91	-12	-675	132	-100	116	285
Miscellaneous crops:										
Tobacco										
Field transplants	--	--	--	--	--	--	--	--	--	--
Plant bed	--	--	385	876	959	--	--	330	876	932
Ornamentals	159	6,314	--	3,588	0	-159	7,763	--	3,588	0
Forest seedling	-396	58	-250	28	1,450	-396	58	-250	28	1,450

-- = Acreage not treated with methyl bromide.

[1]Methyl bromide control is from other crops double-cropped with cucumbers.

[2]In Kentucky, the cost of using MB and alternatives Vorlex and metam-sodium is an estimated $1,000 per acre; thus, there would be no change in control cost.

Table 8--Change in control cost using MB alternatives, with and without Vorlex

Without Vorlex, the change in control cost for the 21 study crops would drop from an estimated $34 million to $26 million in study States (assumes additional pesticides would not be applied during growing season to maintain production).

Crop	California	Florida	Georgia	North Carolina	South Carolina	Selected States
			Million dollars			
With Vorlex						
Fruits/nuts:						
Almonds	-0.9	--	--	--	--	-0.9
Apples	-0.0	--	--	--	--	-0.0
Apricots	-0.0	--	--	--	--	-0.0
Cherries	-0.0	--	--	--	--	-0.0
Citrus[1]	--	-0.5	--	--	--	-0.5
Grapes	-1.2	--	--	--	--	-1.2
Nectarines	-0.1	--	--	--	--	-0.1
Peaches	-0.2	--	--	--	--	-0.2
Plums/prunes	-0.0	--	--	--	--	-0.0
Walnuts	-0.0	--	--	--	--	-0.0
Subtotal	-2.5	-0.5	0.0	0.0	0.0	-3.0
Vegetables:						
Carrots	0.0	--	--	--	--	0.0
Cucumbers	--	--	--	--	--	0.0
Eggplants	--	-0.4	--	--	--	-0.4
Melons	-0.0	-1.1	0.2	0.0	-0.2	-1.2
Peppers	-0.0	3.7	-0.2	0.1	--	3.6
Strawberries	0.9	0.7	--	-0.1	-0.4	1.1
Sweet potatoes	0.0	--	--	--	--	0.0
Tomatoes, fresh	-0.4	16.4	-0.7	0.1	0.0	15.4
Subtotal	0.4	19.3	-0.7	0.1	-0.6	18.5
Tobacco						
Plant bed	--	--	0.3	3.9	0.9	5.1
Ornamentals	-1.0	9.4	--	4.8	--	13.3
Forest seedlings	-0.0	0.0	-0.1	0.0	0.3	0.2
Total	-3.0	28.2	-0.5	8.9	0.6	34.1

Continued

Table 8--Change in control cost using MB alternatives, with and without Vorlex --Continued

Crop	California	Florida	Georgia	North Carolina	South Carolina	Selected States
			Million dollars			
Without Vorlex						
Fruits/nuts:						
Almonds	-0.9	--	--	--	--	-0.9
Apples	-0.0	--	--	--	--	-0.0
Apricots	-0.0	--	--	--	--	-0.0
Cherries	-0.0	--	--	--	--	-0.0
Citrus[1]	--	-0.5	--	--	--	-0.5
Grapes	-1.2	--	--	--	--	-1.2
Nectarines	-0.1	--	--	--	--	-0.1
Peaches	-0.2	--	--	--	--	-0.2
Plums/prunes	-0.0	--	--	--	--	-0.0
Walnuts	-0.0	--	--	--	--	-0.0
Subtotal	-2.5	-0.5	0.0	0.0	0.0	-3.0
Vegetables:						
Carrots	0.0	--	--	--	--	0.0
Cucumbers	--	--	--	--	--	0.0
Eggplants	--	-0.4	--	--	--	-0.4
Melons	-0.0	-1.1	0.2	0.0	-0.2	-1.1
Peppers	-0.0	1.3	0.1	0.1	--	1.5
Strawberries	0.9	0.4	--	-0.1	-0.4	0.8
Sweet potatoes	0.0	--	--	--	--	0.0
Tomatoes, fresh	-0.4	7.2	-0.3	0.2	1.1	7.9
Subtotal	0.4	7.4	0.1	0.2	0.6	8.6
Tobacco						
Plant bed	--	--	0.3	3.9	0.9	5.1
Ornamentals	-1.0	11.6	--	4.8	--	15.4
Forest seedlings	-0.0	0.0	-0.1	0.0	0.3	0.2
Total	-3.1	18.5	0.2	8.9	1.8	26.4

-- = Not available.

[1]MB used to postharvest treat 4,080 trucks at a cost of $120 per truck.

Table 9--Production loss using MB alternatives, with and without Vorlex

For fresh market tomatoes, the production loss of an MB ban (215,000 tons) would more than double without the use of alternative Vorlex.

Crop	California	Florida	Georgia	North Carolina	South Carolina	Selected States
			1,000 tons			
With Vorlex						
Fruits/nuts:						
Almonds	0.077	--	--	--	--	0.077
Apples	2.106	--	--	--	--	2.106
Apricots	0.158	--	--	--	--	0.158
Cherries	0.126	--	--	--	--	0.126
Citrus[1]	--	76.000	--	--	--	76.000
Grapes	13.061	--	--	--	--	13.061
Nectarines	2.009	--	--	--	--	2.009
Peaches	3.965	--	--	--	--	3.965
Plums/prunes	1.554	--	--	--	--	1.554
Walnuts	0.501	--	--	--	--	0.501
Vegetables:						
Carrots	0.014	--	--	--	--	0.014
Cucumbers	--	189.150	--	--	--	189.150
Eggplants	--	26.200	--	--	--	26.200
Melons	4.366	84.800	0.411	0.023	3.150	92.750
Peppers	7.425	191.244	22.950	1.732	--	223.351
Strawberries	65.415	37.382	--	0.832	1.180	104.809
Sweet potatoes	0.118	--	--	--	--	0.118
Tomatoes, fresh	5.147	161.885	16.740	10.220	21.000	214.972
Field crops:						
Tobacco						
Field transplanted	--	--	4.752	29.512	--	34.264
Plant bed	--	--	--	--	--	--
Without Vorlex						
Fruits/nuts:						
Almonds	0.077	--	--	--	--	0.077
Apples	2.106	--	--	--	--	2.106
Apricots	0.158	--	--	--	--	0.158
Cherries	0.126	--	--	--	--	0.126
Citrus[1]	--	76.000	--	--	--	76.000
Grapes	13.061	--	--	--	--	13.061
Nectarines	2.009	--	--	--	--	2.009
Peaches	3.965	--	--	--	--	3.965
Plums/prunes	1.554	--	--	--	--	1.554
Walnuts	0.501	--	--	--	--	0.501
Vegetables:						
Carrots	0.014	--	--	--	--	0.014
Cucumbers	--	189.150	--	--	--	189.150
Eggplants	--	26.200	--	--	--	26.200
Melons	4.366	84.800	0.411	0.023	3.150	92.750
Peppers	7.425	201.965	22.950	2.800	--	235.140
Strawberries	65.415	42.225	--	0.832	1.180	109.652
Sweet potatoes	0.118	--	--	--	--	0.118
Tomatoes, fresh	5.147	404.661	16.740	10.220	21.000	457.768
Field crops:						
Tobacco						
Field transplanted	--	--	5.040	29.512	--	34.552
Plant bed	--	--	--	--	--	--

-- = Not available.

[1]Refers to loss of citrus transported in MB-fumigated trucks.

Table 10--Production loss as a proportion of total crop

Without Vorlex, yield losses of Florida growers would increase up to 46 percent of the crop on acres previously treated with methyl bromide.

Crop	California	Florida	Georgia	North Carolina	South Carolina
	Yield loss as proportion of total crop[1]				
With Vorlex					
Fruits/nuts:					
Almonds	0	--	--	--	--
Apples	1	--	--	--	--
Apricots	0	--	--	--	--
Cherries	0	--	--	--	--
Citrus[2]	--	1	--	--	--
Grapes	0	--	--	--	--
Nectarines	1	--	--	--	--
Peaches	0	--	--	--	--
Plums/prunes	0	--	--	--	--
Walnuts	0	--	--	--	--
Vegetables:					
Carrots	0	--	--	--	--
Cucumbers	--	100	--	--	--
Eggplants	--	100	--	--	--
Melons	1	23	1	0	3
Peppers	3	85	30	3	--
Strawberries	14	59	--	12	31
Sweet potatoes	0	--	--	--	--
Tomatoes, fresh	1	19	45	81	31
Field crops:					
Tobacco					
Field transplanted	--	--	10	10	--
Plant bed	--	--	--	--	--
Without Vorlex					
Fruits/nuts:					
Almonds	0	--	--	--	--
Apples	1	--	--	--	--
Apricots	0	--	--	--	--
Cherries	0	--	--	--	--
Citrus[2]	--	1	--	--	--
Grapes	0	--	--	--	--
Nectarines	1	--	--	--	--
Peaches	0	--	--	--	--
Plums/prunes	0	--	--	--	--
Walnuts	0	--	--	--	--
Vegetables:					
Carrots	0	--	--	--	--
Cucumbers	--	100	--	--	--
Eggplants	--	100	--	--	--
Melons	1	23	1	0	3
Peppers	3	90	30	5	--
Strawberries	14	67	--	12	31
Sweet potatoes	0	--	--	--	--
Tomatoes, fresh	1	46	45	81	31
Field crops:					
Tobacco					
Field transplanted	--	--	11	10	--
Plant bed	--	--	--	--	--

-- = Not available.
[1]Based on yield losses as a proportion of 1989-91 production (USDA, NAPIAP).
[2]Refers to loss of citrus transported in methyl bromide-fumigated trucks.

Table 11--Projected short-term prices with change in production, with and without Vorlex

Lower production of fresh market tomatoes would increase short-term prices by 22 percent with Vorlex availability and 48 percent without Vorlex. Increases in imports would dampen prices considerably.

Crop	Base price/ ton, U.S.	Elasticity of demand	Projected price with: No imports	Projected price with: Imports[1]	Change in price[2,3]: No imports	Change in price[2,3]: Imports
	Dollars/ton	Coefficient	-------- Dollars/ton	(percent) --------		
With Vorlex						
Fruits/nuts:						
Almonds	2,005	-0.3300	2,007	2,007	2 (0)	2 (0)
Apples	289	-0.6700	289	289	0 (0)	0 (0)
Apricots	358	-0.2357	360	360	2 (1)	2 (1)
Cherries	843	-0.2357	844	844	1 (0)	1 (0)
Citrus	301	-1.3780	303	303	2 (1)	2 (1)
Grapes	307	-0.7000	308	308	1 (0)	1 (0)
Nectarines	482	-0.9000	487	487	5 (1)	5 (1)
Peaches	330	-0.9000	331	331	1 (0)	1 (0)
Plums/prunes	317	-0.7000	318	318	1 (0)	1 (0)
Walnuts	1,040	-0.3300	1,047	1,047	7 (1)	7 (1)
Vegetables:						
Carrots	202	-0.5200	202	202	0 (0)	0 (0)
Strawberries	944	-1.2000	1,074	1,055	130(14)	111(12)
Sweet potatoes	258	-0.4070	258	258	0 (0)	0 (0)
Tomatoes, fresh	623	-0.5580	763	665	140(22)	42 (7)
Field crop:						
Tobacco	3,404	-0.5000	3,704	3,434	300 (9)	30 (1)
Without Vorlex						
Fruits/nuts:						
Almonds	2,005	-0.3300	2,007	2,007	2 (0)	2 (0)
Apples	289	-0.6700	289	289	0 (0)	0 (0)
Apricots	358	-0.2357	360	360	2 (1)	2 (1)
Cherries	843	-0.2357	844	844	1 (0)	1 (0)
Citrus	301	-1.3780	303	303	2 (1)	2 (1)
Grapes	307	-0.7000	308	308	1 (0)	1 (0)
Nectarines	482	-0.9000	487	487	5 (1)	5 (1)
Peaches	330	-0.9000	330	330	0 (0)	0 (0)
Plums/prunes	317	-0.7000	318	318	1 (0)	1 (0)
Walnuts	1,040	-0.3300	1,047	1,047	7 (1)	7 (1)
Vegetables:						
Carrots	202	-0.5200	202	202	0 (0)	0 (0)
Strawberries	944	-1.2000	1,080	1,060	136(14)	116(12)
Sweet potatoes	258	-0.4070	258	258	0 (0)	0 (0)
Tomatoes, fresh	623	-0.5580	920	712	297(48)	89(14)
Tobacco	3,404	-0.5000	3,707	3,434	303 (9)	30 (1)

[1]Assumes a proportion of production loss offset by imports in short-term for strawberries (15%), tomatoes (70%), and tobacco (90%).
[2]"Projected price" minus "base price."
[3]Information not available to project prices of cucumbers, eggplants, melons, peppers, ornamentals, and forest seedlings.

Table 12--Projected grower revenue per acre with MB ban, with and without Vorlex[1]

Agricultural imports of fresh market tomatoes and strawberries could moderate price increases and magnify U.S. growers' losses in revenue.

Crop	Base revenue	Projected grower revenue: Without imports	With imports	Difference
		Dollars		
With Vorlex				
Fruits/nuts:				
Almonds	541	542	542	0
Apples	1,415	1,416	1,416	0
Apricots	40	40	40	0
Cherries	220	221	221	0
Citrus	3,551	3,544	3,544	0
Grapes	1,755	1,757	1,757	0
Nectarines	106	106	106	0
Peaches	399	399	399	0
Plums/prunes	270	270	270	0
Walnuts	245	245	245	0
Vegetables:				
Carrots	289	289	289	0
Strawberries	597	567	557	-10
Sweet potatoes	154	154	154	0
Tomatoes, fresh	1,069	1,145	998	-147
Tobacco				
Field transplanted	2,640	2,748	2,547	-201
Without Vorlex				
Fruits/nuts:				
Almonds	541	542	542	0
Apples	1,415	1,416	1,416	0
Apricots	40	40	40	0
Cherries	220	221	221	0
Citrus	3,551	3,544	3,544	0
Grapes	1,755	1,757	1,757	0
Nectarines	106	106	106	0
Peaches	798	798	798	0
Plums/prunes	270	270	270	0
Walnuts	245	245	245	0
Vegetables:				
Carrots	289	289	289	0
Strawberries	597	565	555	-11
Sweet potatoes	154	154	154	0
Tomatoes, fresh	1,069	1,159	897	-262
Tobacco				
Field transplanted	2,640	2,749	2,546	-202

[1]Excludes cucumbers, eggplants, melons, peppers, ornamentals, and forest seedlings.

Table 13--Total economic effect of an MB ban, with and without Vorlex, five States and the United States[1]

For 15 of the 21 study crops, extrapolating the 5-State economic effects to the U.S. level increases the combined grower and consumer effects of an MB ban by $82 million with Vorlex and $112 million without Vorlex.

Affected crop	Five States		United States	
	Proportion of U.S. production	Total effects	Total effects	Difference
	Percent	Million dollars		
With Vorlex				
Almonds	100	0.7	0.7	0.0
Apples	11	-0.4	-3.7	-3.3
Apricots	98	-0.2	-0.2	-0.0
Cherries	11	0.3	2.8	2.5
Citrus	96	-24.5	-25.4	-0.9
Grapes	92	-3.2	-3.5	-0.3
Nectarines	100	-0.9	-0.9	0.0
Peaches	82	-0.8	-1.0	-0.2
Plums/prunes	47	-0.4	-0.8	-0.4
Walnuts	100	-0.9	-0.9	0.0
Subtotal		-30.3	-32.9	-2.6
Vegetables:				
Carrots	94	0.3	0.3	0.0
Strawberries	83	-106.5	-127.8	-21.3
Sweet potatoes	51	0.3	0.6	0.3
Tomatoes, fresh	86	-156.6	-182.5	-25.9
Subtotal		-262.5	-309.3	-46.8
Tobacco	79	-121.2	-154.2	-33.0
Total effects[1]	--	-414.0	-496.4	-82.4
Without Vorlex				
Almonds	100	0.7	0.7	0.0
Apples	11	-0.4	-3.7	-3.3
Apricots	98	-0.2	-0.2	-0.0
Cherries	11	0.3	2.8	2.5
Citrus	96	-24.5	-25.4	-0.9
Grapes	93	-1.9	-3.5	-0.3
Nectarines	100	-0.9	-0.9	0.0
Peaches	87	-0.8	-1.0	-0.2
Plums/prunes	47	-0.4	-0.8	-0.4
Walnuts	100	-0.9	-0.9	0.0
Subtotal		-29.0	-32.9	-2.6
Vegetables:				
Carrots	94	0.3	0.3	0.0
Strawberries	83	-111.4	-133.6	-22.2
Sweet potatoes	51	0.3	0.6	0.3
Tomatoes, fresh	86	-327.4	-381.5	-54.1
Subtotal		-438.2	-514.3	-76.1
Tobacco	79	-122.2	-155.5	-33.3
Total effects[2]	--	-589.4	-702.7	-112.0

-- = Not applicable.

[1]Total effects assume imports in short term of strawberries, tomatoes, and tobacco.

[2]Excludes effects on cucumbers, eggplants, melons, peppers, ornamentals, and forest seedlings.

Table 14--Methyl bromide ban: Summary of six affected crops, change in control cost and production loss, with and without Vorlex

The loss in tomato production from a methyl bromide ban would more than double without alternative Vorlex. For those crops for which other feasible fumigant alternatives are not available, fumigation cost would be reduced.

Total cost and loss by affected crop	With Vorlex	Without Vorlex	Difference
	Million dollars		Percent
Total control cost:			
Melons	-1.2	-1.1	-8
Peppers	3.6	1.5	-58
Strawberries	1.1	0.8	-27
Tomatoes	15.4	7.9	-49
Tobacco	5.1	5.1	0
Ornamentals	13.3	15.4	16
Total	37.3	29.6	-21
	1,000 Tons		
Total production loss:			
Melons	92.7	92.7	0
Peppers	223.4	235.1	5
Strawberries	104.8	109.7	5
Tomatoes	215.0	457.8	113
Tobacco	34.3	34.6	1
Ornamentals[1]	--	--	--

-- = Not available.
[1]Loss of production in millions of plants (USDA, NAPIAP).

Table 15--Methyl bromide ban: Summary of change in economic effects on six affected crops, with and without Vorlex and with and without imports

Imports would dampen the short-term price increases of a ban and lower consumer prices, but reduce net returns to growers. Without Vorlex, imports of tomatoes would reduce the effects of a methyl bromide ban on consumer cost from $443 million to $147 million, and change grower returns from a gain of $90 million to a loss of $173 million.

	With Vorlex		Without Vorlex	
Item	No imports	Imports	No imports	Imports
		Dollars		
Projected price per ton:				
Strawberries	1,074	1,055	1,080	1,060
Tomatoes	763	665	920	712
Tobacco	3,704	3,434	3,707	3,434
		Million dollars		
Projected grower revenue:				
Strawberries	-30	-40	-32	-43
Tomatoes	76	-71	90	-173
Tobacco	108	-93	109	-94
Change in consumer cost:				
Strawberries	76	65	79	68
Tomatoes	225	70	443	147
Tobacco	228	23	230	23
Total effect:[1]				
Melons	-28	-28	-29	-29
Peppers	-131	-131	-135	-135
Strawberries	-107	-107	-112	-111
Tomatoes	-164	-157	-361	-327
Tobacco	-125	-121	-127	-122
Ornamentals	-163	-163	-170	-170

[1]No imports assumed in short term for melons, peppers, and ornamentals.

Appendix A—Methodology

Economic Model

A model is used to estimate the change in net revenue to growers, the increased cost to consumers, and the overall total effect of a methyl bromide ban that results in changes in control cost and yield. The change in growers' production and projected price effects are used to determine the changes in grower and consumer surplus. A similar model was used in a 1988 assessment of methyl bromide and other fumigants (Barse and others, 1988).

The short-term economic specifications of a methyl bromide ban are expressed in equation 1 for a particular crop i + scenario j, where the superscripts b and a refer to periods before and after the ban with associated loss in yield. Farm-level price elasticities of demand are used to derive the new equilibrium price to reflect the change in production:

$$P^a_{ij} = P^b_i(1/E_i^d X_{ij} + 1), \quad X_{ij} = (Q_{ij}^b - Q_{ij}^a)/Q_{ij}^b \qquad (1)$$

where:

P^a_{ij} = price after change in production for crop i, scenario j;
P^b_{ij} = base price for crop i, scenario j;
E_i^d = price elasticity of demand for crop i; and
X_{ij} = percent change in production due to infestation for crop i, scenario j.

At the initial equilibrium position, with methyl bromide available, total revenue from the sale of the crop equals P^bQ^b, or area e+f+g+h+i (figure 8(c)). The initial surplus accruing to growers equals area e+f+g. With higher cost and lower yield resulting from use of alternative control, the change in grower surplus, or area b-f-g, equals the change in total revenue, area b+c-g-i, minus the change in total cost, area c+f-i. This change in grower surplus could be positive or negative, depending on the price elasticities of demand and supply curves, and is measured as follows:

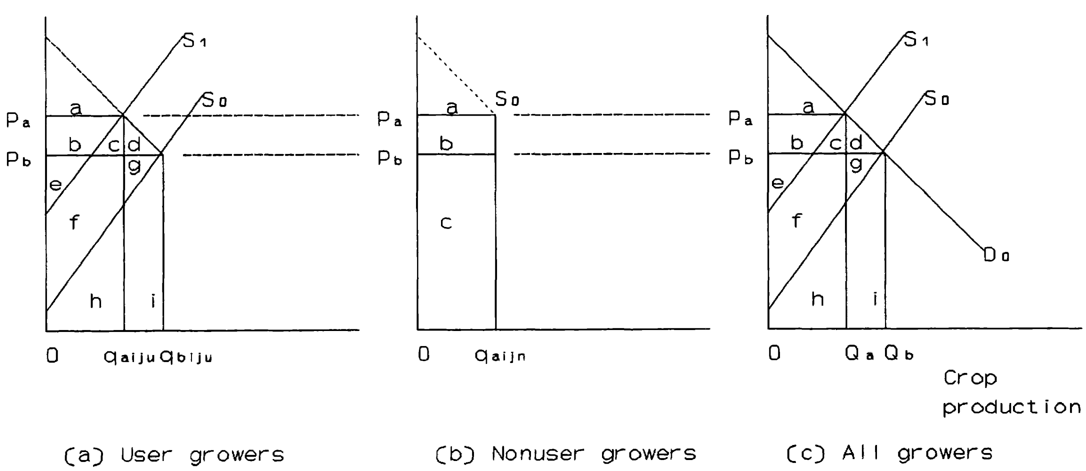
$$I^P_{ij} = (P^a_{ij}Q^a_{ij}) - (P^b_iQ^b_i) - (A^aT_{ij}C^a_{ij}) \qquad (2)$$

where:

I^P = effect on growers of crop i
P = price per unit of crop (farm level)

Figure 8

Effects of a pesticide ban



Q = total production of crop i, or acres planted x yield
A = acres planted of crop i
T = proportion of planted acres affected of crop i
C = change in control cost per acre for crop i.

The short-term implications of higher prices would affect both previous users and nonusers of the banned pesticide. The effect on growers who previously used the pesticide can be determined by the change in surplus on acreage affected by the ban, illustrated by area -b+f+g in figure 8(a), and measured by:

$$I^u_{ij} = (P^a_{ij}q^a_{iju}T_{ij}) - (P^b_i q^b_{iju}T_{ij}) - (A_i{}^aT_{ij}C^a_{ij}) \tag{3}$$

where:

I^u = effect on user growers
T = proportion of planted acres affected, crop i, scenario j.

Given perfect elasticity in the market for alternative controls, growers not having a pest problem or already using the alternatives to the banned pesticide would benefit from the higher crop prices without incurring cost increases (fig. 8(b)). The effect on nonuser growers can be derived by simply subtracting the effect on user growers, from the effect on all growers, or by using a procedure similar to those indicated in equations (3) and (4):

$$I^n_{ij} = (P^a_{ij}q^a_{ijn}R) - (P^b_i q^b_{ijn}R),\ q^a iju = Q^a_{iju} - qa^{iju},\ Q^b_{iju} - qb^{iju} \tag{4}$$

where:

I^n = effect on nonuser growers
R = proportion of planted acres not affected.

Consumers' willingness to purchase production Q^b is the entire area under the demand curve between zero and Q^b, or area a+b+...+h+i in figure 8(c). At equilibrium market price, P^b, consumers pay only area e+f+g+h+i. Thus, the net benefit of having the pesticide available is area a+b+c+d. The pesticide use ban results in the loss of consumer surplus area (b+c+d), measured as follows:

$$I^c_{ij} = (P^b_{ij}Q^a_{ij})-(P^a_iQ^a_i)+0.5(P^a_{ij}-P^b_i)(Q^a_{ij}-Q^b_i) \tag{5}$$

where:

I^c = effect on consumers of crop i.

The total change in welfare, or the effect on society, is defined as the change in grower surplus plus the change in consumer surplus, or area -(c+d+f+g) in figure 8(c). This area reflects the change in real income redistribution - (c+f+g) plus the net loss in efficiency, area d, measured by simply adding change in grower surplus to the change in consumer surplus, or:

$$I^d_{ij} = I^p_{ij} + I^c_{ij} \tag{6}$$

where:

I^d = total effect on grower net returns and consumer cost.

The effect of a pesticide ban is to transfer income from consumers to growers through a higher price due to lower yield in the short-term, and passed-on higher production cost in the long term as marginal growers shift out of production. A pesticide ban will likely cause a net loss in economic efficiency and a redistribution of income from consumers to growers, with windfall gains to nonuser growers, and gains or losses in benefits to user growers, depending on the crop's price elasticities of demand, and the supply and cost of alternative control. The longer term effect of several years without new improved alternative control is loss of domestic and foreign markets, as growers shift into production of substitute crops.

Model Assumptions and Limitations

The cost-benefit methodology used in deriving the short-term economic effects that occur during the first year of a methyl bromide ban entail a number of major assumptions and limitations:

1. The estimates reflect short-term effects only. Among the longer term mechanisms not included are biological constraints, such as longer term reduction in the vigor and yield of perennial crops, for example, the fruit and nut tree crops; increases or decreases in planted acreage; or commodity imports which might substitute for and compete with the domestic crops studied.

2. The economic analysis does not include changes in the value of land, equipment, and other capital assets that might result from a methyl bromide ban.

3. Base year acres treated, costs, yields, and price elasticities of demand reflect the average yield of all growers of a specified crop in a typical or average production and consumption year.

4. Yield estimates with use of alternatives take into account the various responses of different cultivars and represent the total crop.

5. The utility of each dollar gained or lost is constant across various economic classes of growers and consumers.

6. The effects do not quantify any economic implications of changes involving indemnification to farmers and manufacturers for pesticide inventories or changes in enforcement cost. Further, the short-term effects do not take into account cost implications of changes in demand for alternative pesticides. For example, the supply functions for grower purchased inputs (labor, equipment, and alternative pesticides) in each scenario are perfectly elastic.

Sources of Databases and Price Elasticities of Demand

The primary database for yield losses using methyl bromide chemical alternatives, rates, comparative cost, quantities of methyl bromide active ingredients used, and other biological related information was obtained from the USDA methyl bromide assessment team (USDA,NAPIAP). Base estimates of U.S. level production, acres planted, and prices were obtained from various USDA published estimates (USDA, ERS and USDA, NASS). Price elasticities of demand estimates were developed from published and unpublished sources (Brandt and King; Grise; Huang).

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U.S. Department of Agriculture
Economic Research Service

SUMMARY OF REPORT #TB-1827

Effectiveness of Integrated Pest Control Depends on Local Environments

December 1993

Contact: Margriet F. Caswell or Robbin A. Shoemaker, (202) 219-0434

The success of adopting new farming practices to reduce the use of pesticides depends on the environmental characteristics of the area in which the practices are used. The U.S. Department of Agriculture has proposed that farmers reduce the use of pesticides by adopting integrated pest management strategies, a system in which farmers choose pest management practices appropriate to the specific environment. These practices have been promoted through the USDA Water Quality Initiative in response to public concerns about possible chemical contamination of groundwater from agriculture. Adoption of the practices would be encouraged through a combination of education and cost-sharing programs. Under some environmental conditions, integrated pest management shows promise of reducing pollution of ground and surface water.

Techniques Must Be Chosen for Local Conditions

The effectiveness of an integrated pest management technique depends on local environmental conditions. IPM practices have a range of very different technical and physical or biological relationships. The programs make use of chemical, biological, cultural, mechanical, and genetic techniques. This report, *Adoption of Pest Management Strategies Under Varying Environmental Conditions* from USDA's Economic Research Service, provides a technical analysis of several policy instruments designed to encourage the adoption of chemical-reducing pest management strategies. A model is developed that provides an analysis of systematic differences among possible techniques as these relate to the specific environment and describes the effects of these techniques if they were put into place.

The choice of the best pest management strategy depends on such factors as land quality, climate, degree of infestation, and other local considerations. Pesticide loadings (the amount of chemical available for runoff or leaching) can be determined for a range of environmental characteristics. The resulting water quality will depend on the correlation of the environment with the amount of chemical residuals.

Two Pest Management Strategies Cited

Two types of IPM strategies--biological controls and crop rotation--illustrate the effectiveness of alternative practices in reducing chemical loadings. The profits associated with alternative practices, which will affect voluntary adoption of the practices, are examined. The reasons for choosing the methods are derived, and the sensitivity of the choices to environmental, technological, and economic factors is discussed. An analysis follows of the effects of the methods on farmer profitability, land use, and chemical loadings when the new techniques are in use.

To Order This Report...

The information presented here is excerpted from ***Adoption of Pest Management Strategies Under Varying Environmental Conditions,*** TB-1827, by Margriet F. Caswell and Robbin A. Shoemaker. The cost is $9.00.

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